Application of metaheuristics through MATLAB optimisation toolboxes for the design of coupled resonator filters

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1 Introduction

There is a large number of applications in the design of telecommunication devices where it is necessary to apply optimisation techniques to find the best values for a set of parameters [2, 5]. Normally, it is not possible to solve those optimisation problems with analytical techniques, and the alternative is to use metaheuristic methods [6].

In this work we tackle the problem of designing coupled resonator filters [1], which are used in the RF-frontends of communication devices. There are different phases in the design of these filters. In a first approximation, the desired topology of the filter and the basic characteristics of the technology to use are established, and then it is necessary to obtain the theoretical coupling matrix which implements the desired transfer function. We analyse the application of metaheuristics to obtain that matrix.

Furthermore, the numerical software Matlab is frequently used to work on the design of those devices, and a good option would be to also develop in Matlab the optimisation tools. Thus, this work analyses the application of Matlab optimisation *toolboxes* to tackle this optimisation problem with different metaheuristics. A detailed experimental analysis is carried out to obtain the tools in Matlab which best fit the problem, and some tools are personalised to improve the quality of the design.

2 Matlab toolboxes and metaheuristics

Matlab version *R2008a* has two *toolboxes* for optimisation:

- *Optimization Toolbox* [4] includes different optimisation functions. In our analysis the local search tool `fmincon` is used.
- *Genetic Algorithm and Direct Search Toolbox* [3] is dedicated to genetic algorithms and direct search for global optimisation problems. It includes routines for:
  - Direct Search (`patternsearch`)
  - Genetic Algorithms (`ga`)
  - Simulated Annealing (`simulannealbnd`)

Furthermore, in many cases the functions in the metaheuristics can be personalised to adapt the method to the problem we are working with.

3 Computational experiments

Experiments were carried out for six designs, four with nine design parameters to be optimised, and two with eight design parameters. In all the cases, the parameters take real values between -5 and 5.

The methodology used was:

- For each tool, the significant parameters in the metaheuristic for the problem were identified, and the other parameters were fixed to the default value.

– Each parameter was evaluated independently, with the other parameters having a fixed value, except for parameters whose interaction is known. In that case, the different combinations between the dependent parameters were considered.
– When an initial point is needed for the optimisation process, this point has been randomly generated, and the same value has been used for all the configurations.
– For each configuration, the experiments were repeated several times, and the mean is calculated.

Figure 1 summarises the results obtained once the parameters of each method had been tailored for the problem. It shows the mean of the fitness value for each method applied to the six filter configurations. The best results are obtained with `ga`, which has been hybridised with a direct search (using `fmincon`), which is used in the generation of the initial population and after mutation of an element.

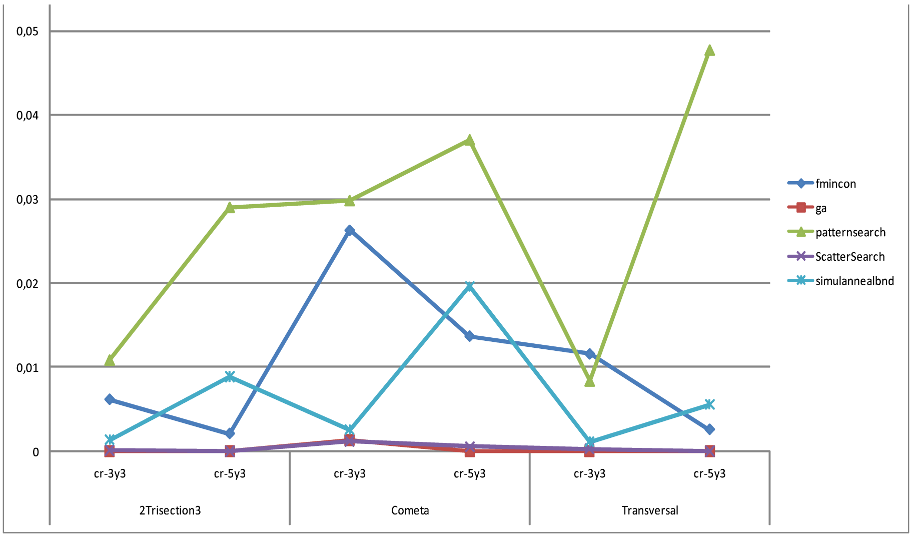

Fig. 1. Mean of the fitness function for the different optimisation methods and design problems.

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References

1. R. J. Cameron. General coupling matrix synthesis methods for Chebyshev filtering functions. *IEEE Transactions on Microwave Theory and Techniques*, 47:433–442, 1999.
2. C. Feremans, M. Labb, and G. Laporte. Generalized network design problems. *European Journal of Operational Research*, 148(1):1–13, July 2003.
3. The MathWorks, http://www.mathworks.com. *Genetic Algorithm and Direct Search Toolbox User's Guide*. Version 2.3.
4. The MathWorks, http://www.mathworks.com. *Optimization Toolbox User's Guide*. Version 4.0.
5. J. Nocedal and S. J. Wright. *Numerical Optimization*. Springer, New York, second edition, 2006.
6. C. C. Ribeiro, S. L. Martins, and I. Rosseti. Metaheuristics for optimization problems in computer communications. *Computer Communications*, 30:656–669, 2007.